

Chemistry
Higher level
Paper 1

Friday 13 November 2015 (afternoon)

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[40 marks]**.

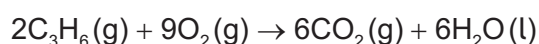
The Periodic Table

1	2	3	4	5	6	7	0										
<div>1 H 1.01</div>		<div>Atomic number</div> <div>Element</div> <div>Relative Atomic Mass</div>						<div>2 He 4.00</div>									
<div>3 Li 6.94</div>	<div>4 Be 9.01</div>							<div>9 F 19.00</div>									
<div>11 Na 22.99</div>	<div>12 Mg 24.31</div>							<div>17 Cl 35.45</div>									
<div>19 K 39.10</div>	<div>20 Ca 40.08</div>	<div>21 Sc 44.96</div>	<div>22 Ti 47.90</div>	<div>23 V 50.94</div>	<div>24 Cr 52.00</div>	<div>25 Mn 54.94</div>	<div>26 Fe 55.85</div>	<div>27 Co 58.93</div>	<div>28 Ni 58.71</div>	<div>29 Cu 63.55</div>	<div>30 Zn 65.37</div>	<div>31 Ga 69.72</div>	<div>32 Ge 72.59</div>	<div>33 As 74.92</div>	<div>34 Se 78.96</div>	<div>35 Br 79.90</div>	<div>36 Kr 83.80</div>
<div>37 Rb 85.47</div>	<div>38 Sr 87.62</div>	<div>39 Y 88.91</div>	<div>40 Zr 91.22</div>	<div>41 Nb 92.91</div>	<div>42 Mo 95.94</div>	<div>43 Tc 98.91</div>	<div>44 Ru 101.07</div>	<div>45 Rh 102.91</div>	<div>46 Pd 106.42</div>	<div>47 Ag 107.87</div>	<div>48 Cd 112.40</div>	<div>49 In 114.82</div>	<div>50 Sn 118.69</div>	<div>51 Sb 121.75</div>	<div>52 Te 127.60</div>	<div>53 I 126.90</div>	<div>54 Xe 131.30</div>
<div>55 Cs 132.91</div>	<div>56 Ba 137.34</div>	<div>57 † La 138.91</div>	<div>72 Hf 178.49</div>	<div>73 Ta 180.95</div>	<div>74 W 183.85</div>	<div>75 Re 186.21</div>	<div>76 Os 190.21</div>	<div>77 Ir 192.22</div>	<div>78 Pt 195.09</div>	<div>79 Au 196.97</div>	<div>80 Hg 200.59</div>	<div>81 Tl 204.37</div>	<div>82 Pb 207.19</div>	<div>83 Bi 208.98</div>	<div>84 Po (210)</div>	<div>85 At (210)</div>	<div>86 Rn (222)</div>
<div>87 Fr (223)</div>	<div>88 Ra (226)</div>	<div>89 ‡ Ac (227)</div>															
		†	<div>58 Ce 140.12</div>	<div>59 Pr 140.91</div>	<div>60 Nd 144.24</div>	<div>61 Pm 146.92</div>	<div>62 Sm 150.35</div>	<div>63 Eu 151.96</div>	<div>64 Gd 157.25</div>	<div>65 Tb 158.92</div>	<div>66 Dy 162.50</div>	<div>67 Ho 164.93</div>	<div>68 Er 167.26</div>	<div>69 Tm 168.93</div>	<div>70 Yb 173.04</div>	<div>71 Lu 174.97</div>	
		‡	<div>90 Th 232.04</div>	<div>91 Pa 231.04</div>	<div>92 U 238.03</div>	<div>93 Np (237)</div>	<div>94 Pu (242)</div>	<div>95 Am (243)</div>	<div>96 Cm (247)</div>	<div>97 Bk (247)</div>	<div>98 Cf (251)</div>	<div>99 Es (254)</div>	<div>100 Fm (257)</div>	<div>101 Md (258)</div>	<div>102 No (259)</div>	<div>103 Lr (260)</div>	

1. Which compound's molecular formula is the same as its empirical formula?

- A. $\text{C}_2\text{H}_5\text{OH}$
- B. CH_3COOH
- C. C_6H_6
- D. C_8H_{18}

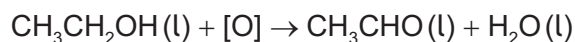
2. The equation for the **complete** combustion of propene, C_3H_6 , is shown below.



Which mixture, when ignited, will lead to **incomplete** combustion and the formation of $\text{CO}(\text{g})$?

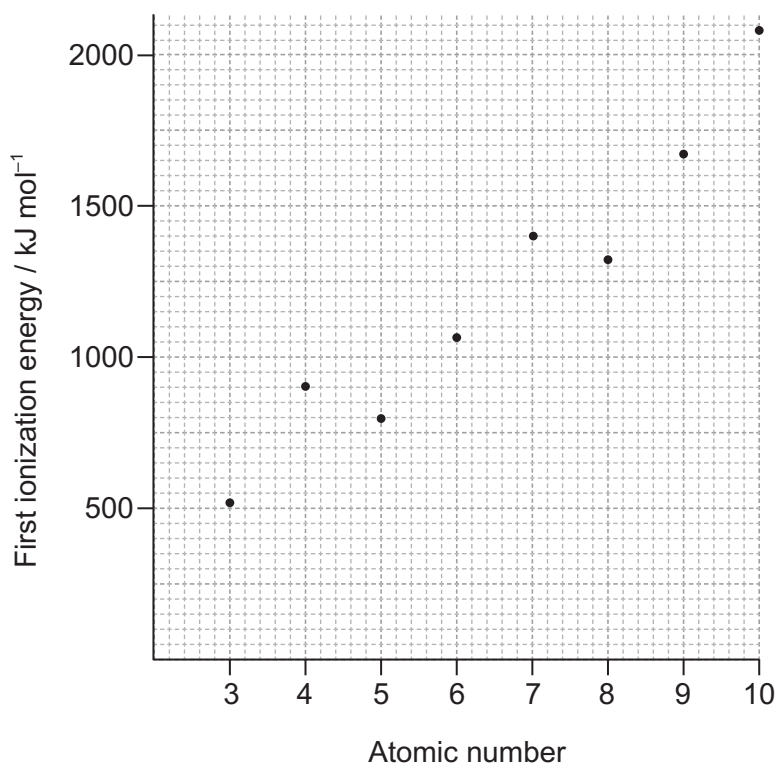
- A. 2 dm^3 of propene and 10 dm^3 of oxygen
- B. 0.5 dm^3 of propene and 2.3 dm^3 of oxygen
- C. 1 dm^3 of propene and 4 dm^3 of oxygen
- D. 3 dm^3 of propene and 14 dm^3 of oxygen

3. What is the percentage yield when 1.1 g of ethanal, CH_3CHO , is obtained from 4.6 g of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$? $M_r(\text{CH}_3\text{CH}_2\text{OH}) = 46$; $M_r(\text{CH}_3\text{CHO}) = 44$



- A. $\frac{1.1 \times 46 \times 100}{44 \times 4.6}$
- B. $\frac{1.1 \times 100}{4.6}$
- C. $\frac{4.6 \times 44 \times 100}{4.6 \times 1.1}$
- D. $\frac{1.1 \times 46}{44 \times 4.6}$

4. Which stage of operation immediately follows ionization in the mass spectrometer?
- Acceleration
 - Deflection
 - Detection
 - Vaporization
5. Which statement is correct about the first ionization energies of consecutive elements shown in the graph?



[Source: Values from Nuffield Advance Science - Book of Data, Revised Edition (1984)]

- The graph falls between Be and B because there is an electron in the third energy level.
- The graph increases from B to N because the atomic radius is increasing.
- The graph increases from Li to Ne because the number of electrons is increasing.
- The graph falls between Be and B because the outer electron in B is in a p sub-level.

6. Which element has the greatest first ionization energy?
- A. Al
 - B. Ar
 - C. Cl
 - D. Cs
7. Which elements are in the same group of the periodic table?
- A. Ca, Na, Rb, Sr
 - B. Al, Ar, Cl, S
 - C. Au, Hg, Pb, Pt
 - D. As, Bi, P, Sb
8. Which property of transition metals enables them to behave as catalysts?
- A. High melting point
 - B. Variable oxidation number
 - C. High density
 - D. Split d sub-levels
9. Which statement best describes the lattice structure of solid sodium chloride?
- A. Each sodium ion is surrounded by one chloride ion.
 - B. Each chloride ion is surrounded by two sodium ions.
 - C. Each chloride ion is surrounded by four sodium ions.
 - D. Each sodium ion is surrounded by six chloride ions.
10. Which compound is most likely to contain ionic bonding?
- A. ClO_2
 - B. CsCl
 - C. SCl_2
 - D. SiCl_4

11. Which molecule is polar?

- A. C_2H_6
- B. CH_2Cl_2
- C. CO_2
- D. CCl_4

12. What is the shape of the hexacyanoferrate(III) ion, $[\text{Fe}(\text{CN})_6]^{3-}$?

- A. Square planar
- B. Hexagonal
- C. Octahedral
- D. Trigonal bipyramidal

13. Which set contains two or more species with delocalized π electrons?

- A. CH_3CH_3 , $\text{H}_2\text{C}=\text{CH}_2$, $\text{H}_2\text{C}=\text{O}$
- B. NaCl , C_6H_6 , $\text{H}_2\text{C}=\text{O}$
- C. CO_3^{2-} , C_6H_6 , C_6H_{12}
- D. O_2 , CH_3COCH_3 , $\text{CH}_3\text{COOCH}_3$

14. Which of the following changes are exothermic?

- I. $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- II. $2\text{C}_8\text{H}_{18}(\text{g}) + 17\text{O}_2(\text{g}) \rightarrow 16\text{CO}(\text{g}) + 18\text{H}_2\text{O}(\text{g})$
- III. $\text{C}_8\text{H}_{18}(\text{g}) \rightarrow \text{C}_8\text{H}_{18}(\text{l})$

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

15. Which change represents the standard enthalpy change of formation?
- A. The formation of 1 mol of a compound in its standard state from its gaseous atoms
 - B. The formation of 1 mol of a compound in its standard state from its elements
 - C. The formation of 1 mol of a compound in its standard state from its gaseous atoms in their standard states
 - D. The formation of 1 mol of a compound in its standard state from its elements in their standard states

16. Which equation represents electron affinity?

- A. $\text{C(g)} + \text{e}^- \rightarrow \text{C}^-(\text{g})$
- B. $\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na(s)}$
- C. $\frac{1}{2}\text{Cl}_2(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- D. $\text{B(g)} + \text{e}^- \rightarrow \text{B}^+(\text{g}) + 2\text{e}^-$

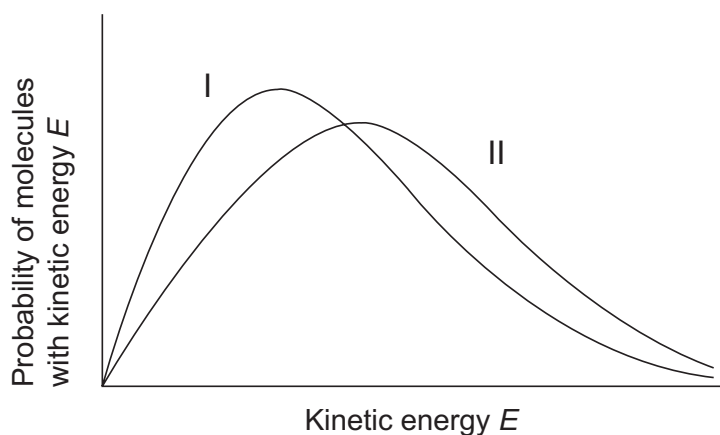
17. Which combination results in an ionic compound having the **greatest** magnitude of lattice enthalpy?

	Sum of ionic radii	Ionic charges
A.	small	large
B.	large	large
C.	large	small
D.	small	small

18. Under which conditions does a sample of the same mass of carbon dioxide have the **lowest** entropy value?

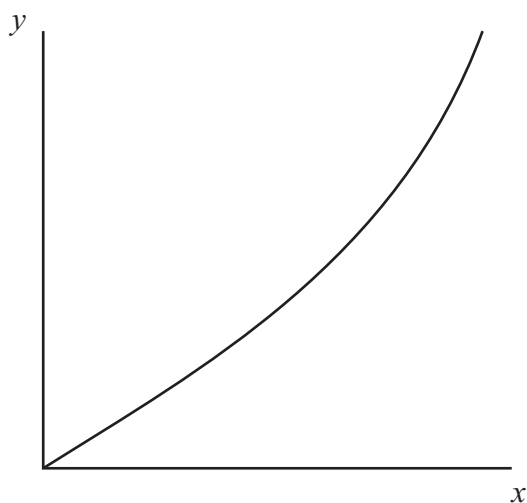
- A. Solid at high temperature
- B. Solid at low temperature
- C. Gas at high temperature
- D. Gas at low temperature

19. Curves I and II represent samples of the same gas at a constant pressure but at different temperatures. The areas under curves I and II are equal. What does curve II represent?



- A. Curve II is at the lower temperature and there are less molecules in the sample.
- B. Curve II is at the lower temperature and there are the same number of molecules in the samples.
- C. Curve II is at the higher temperature and there are more molecules in the sample.
- D. Curve II is at the higher temperature and there are the same number of molecules in the samples.

20. The graph shows a plot for a reaction with second-order kinetics. How should the axes be labelled?



	x-axis	y-axis
A.	concentration	time
B.	time	concentration
C.	rate	concentration
D.	concentration	rate

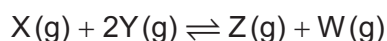
21. Which factors affect the rate constant, k , of a reaction?

- I. Catalyst
 - II. Concentration of reactants
 - III. Temperature
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

22. Which best describes a reaction in a state of equilibrium?

- A. The rates of the forward and reverse reactions are zero and the concentrations of products and reactants are equal.
- B. The rate of the forward reaction equals the rate of the reverse reaction and the concentrations of products and reactants are equal.
- C. The rates of the forward and reverse reactions are zero and the concentrations of products and reactants are constant.
- D. The rate of the forward reaction equals the rate of the reverse reaction and the concentrations of products and reactants are constant.

23. The equilibrium concentrations of X, Y, Z and W are 1, 2, 4 and 2 mol dm⁻³ respectively.



What is the value of the equilibrium constant, K_c ?

- A. 0.25
- B. 0.5
- C. 2
- D. 4

24. Which of the following molecules can act as a Lewis acid but not as a Brønsted–Lowry acid?

- A. BF_3
- B. PCl_3
- C. NH_3
- D. H_2O

25. Which is a 0.001 mol dm⁻³ solution of a weak acid?

	Conductivity	pH
A.	poor	5
B.	good	7
C.	poor	10
D.	good	3

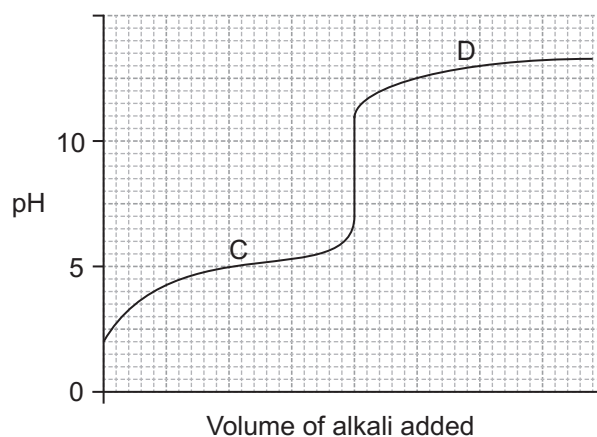
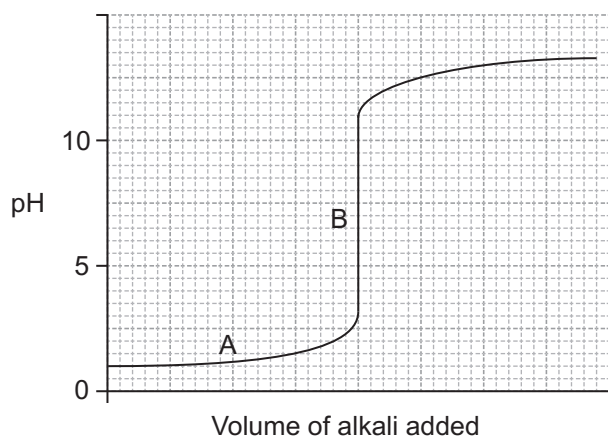
26. What is the order of increasing acid strength? Approximate K_a and pK_a values at 298 K are given.

	K_a		pK_a
ClCH_2COOH	1×10^{-3}	$\text{C}_6\text{H}_5\text{OH}$	10.0
$\text{CH}_3\text{CH}_2\text{COOH}$	1×10^{-5}	$\text{C}_6\text{H}_5\text{NH}_3^+$	4.6

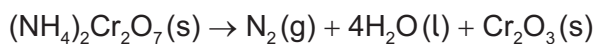
- A. $\text{ClCH}_2\text{COOH} < \text{CH}_3\text{CH}_2\text{COOH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{C}_6\text{H}_5\text{OH}$
- B. $\text{C}_6\text{H}_5\text{OH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{ClCH}_2\text{COOH} < \text{CH}_3\text{CH}_2\text{COOH}$
- C. $\text{C}_6\text{H}_5\text{OH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{CH}_3\text{CH}_2\text{COOH} < \text{ClCH}_2\text{COOH}$
- D. $\text{C}_6\text{H}_5\text{OH} < \text{CH}_3\text{CH}_2\text{COOH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{ClCH}_2\text{COOH}$
27. Which solutions, mixed in equal concentrations and volumes, form an acid buffer solution?
- A. $\text{HCl(aq)} + \text{NaCl(aq)}$
- B. $\text{CH}_3\text{CO}_2\text{H(aq)} + \text{CH}_3\text{CO}_2\text{Na(aq)}$
- C. $\text{CH}_3\text{CO}_2\text{H(aq)} + \text{NaOH(aq)}$
- D. $\text{CH}_3\text{CO}_2\text{H(aq)} + \text{CH}_3\text{CH}_2\text{CO}_2\text{H(aq)}$
28. Which salt forms the most acidic solution when dissolved in water?

	Salt	Ionic radius of cation / 10^{-12} m
A.	CrCl_3	63
B.	FeCl_2	76
C.	MgCl_2	65
D.	NaCl	98

29. What is the buffer region in the acid–base titration curves below?



30. Which element undergoes reduction in the following reaction?

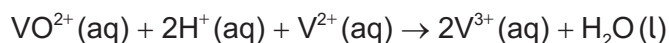


- A. Cr
- B. H
- C. N
- D. O

31. Which best describes reduction?

- A. Increase in oxidation number and gain of electrons
- B. Increase in oxidation number and loss of electrons
- C. Decrease in oxidation number and gain of electrons
- D. Decrease in oxidation number and loss of electrons

32. What is E^\ominus , in V, for the following reaction?



	Standard electrode potential, E^\ominus / V
$\text{V}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{V}(\text{s})$	–1.18
$\text{V}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{V}^{2+}(\text{aq})$	–0.26
$\text{VO}^{2+}(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+0.34
$\text{VO}_2^+(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{VO}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+1.00

- A. –0.60
- B. +0.08
- C. +0.60
- D. +1.26
33. What product is formed at the positive electrode (anode) when $0.001 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4(\text{aq})$ is electrolysed?
- A. Hydrogen
- B. Oxygen
- C. Sulfur
- D. Sulfur dioxide
34. Which pair of compounds can be distinguished by reacting them with dilute bromine water in the dark?
- A. $\text{CH}_3\text{CH}_2\text{COOH}$ and $\text{CH}_3\text{CH}_2\text{CHO}$
- B. $\text{CH}_3\text{CH}_2\text{CHCHCH}_3$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- C. $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)_2$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHBrCH}_3$ and $\text{CH}_3\text{CH}_2\text{CHBrCH}_2\text{CH}_3$

35. Which compound is most soluble in water?

- A. $\text{CH}_3\text{CH}_2\text{CHO}$
- B. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
- C. $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
- D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$

36. Which are features of successive members of a homologous series?

- I. Similar chemical properties
- II. Same general formula
- III. Differ by $-\text{CH}_2-$

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

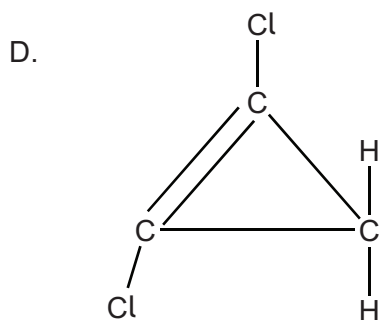
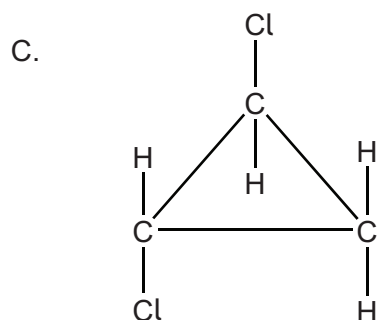
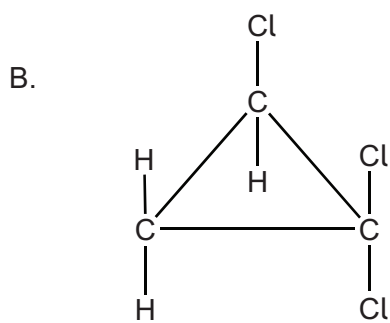
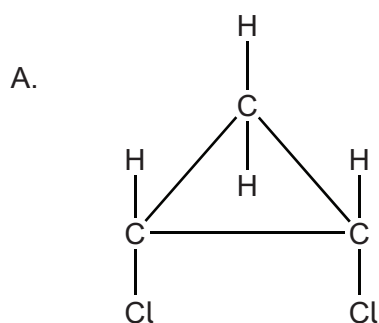
37. Which formula represents propanenitrile?

- A. $\text{CH}_3\text{CH}_2\text{CN}$
- B. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
- C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$
- D. $\text{CH}_3\text{CH}(\text{NH}_2)\text{CH}_3$

38. Which halogenoalkane reacts fastest with warm $\text{NaOH}(\text{aq})$?

- A. $(\text{CH}_3)_3\text{CCl}$
- B. $(\text{CH}_3)_3\text{CBr}$
- C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$
- D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$

39. Which is the geometric isomer of *cis*-1,2-dichlorocyclopropane?



40. Which is the best-fit line or best-fit curve for the points plotted on the graph?

